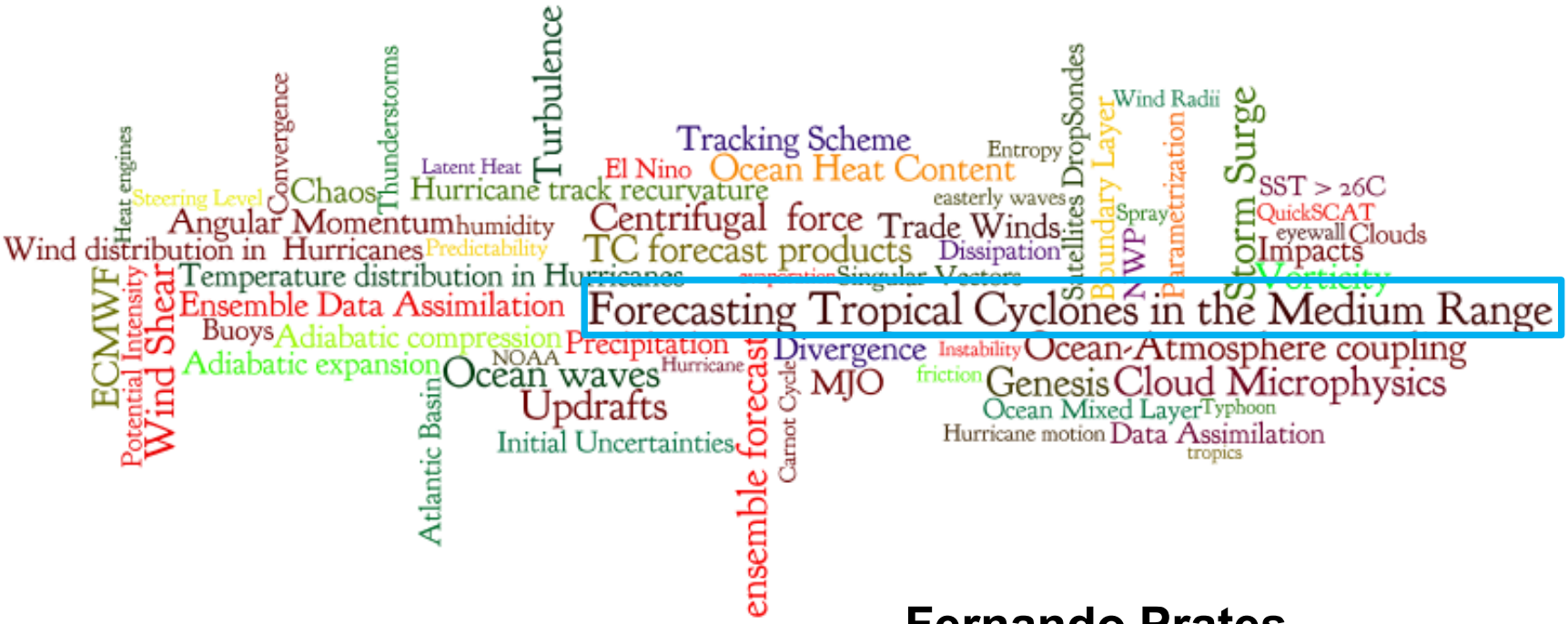


Fernando Prates

Evaluation Section

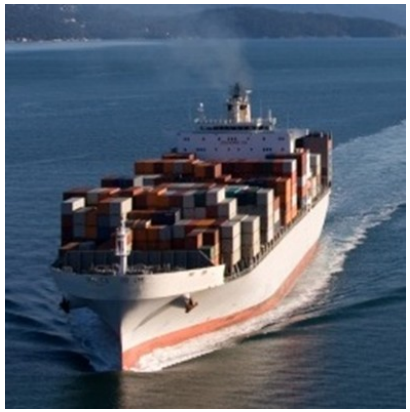
Objectives

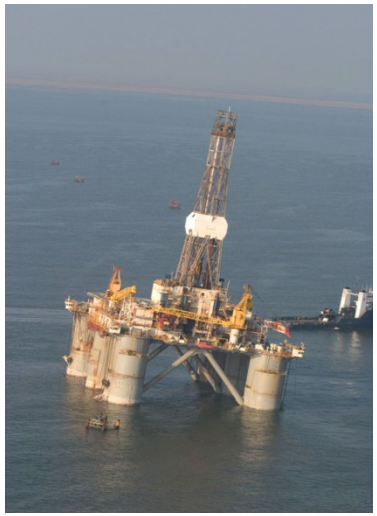
- Have a better understanding of the Tropical Cyclone Products generated at ECMWF
- Learn the recent developments in the forecast system and its impact on the Tropical Cyclone forecast
- Learn about the skill of TC forecasts in recent years

Why is so important to forecast Tropical Cyclones?

- Tropical cyclone can cause massive loss of life in highly dense populated areas; STY Hayan in Philippines (2013); TC Nargis in Myanmar (2008), …
  - Fact: Storm surge is the main cause of human fatalities

- They can cause major disruptions on economic activities
  - Off shore oil rigs
  - Ship routing





Why TC forecasts have improved in recent years?

Due to the continuous upgrades of the forecast system at ECMWF,

- Increase of model horizontal and vertical resolution
- Massive use of Satellite data in Data Assimilation (DA)
- Improvements of the physical processes (parametrization of convection, new cloud microphysics,…)
- Methods for Global Ensemble Prediction : ENS evolved SVs , stochastic physics and perturbations target at observed TCs and **more recently** the implementation of Ensemble Data Assimilation
- From last November:
  - *The atmosphere-ocean coupling of the ENS is active from initial time of the forecast using a new version of the NEMO ocean model (cy40r1)*

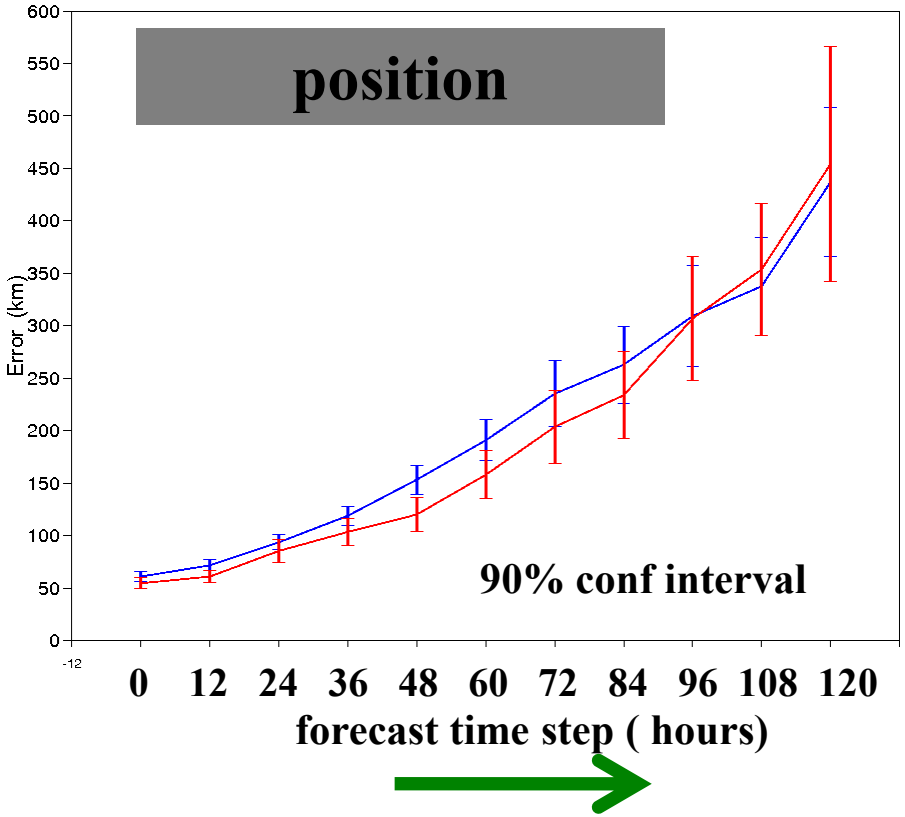
….. At ECMWF there is no artificial bogus vortex scheme for TCs. We allow the observations to do their job …..

Click me to jump to the next slide

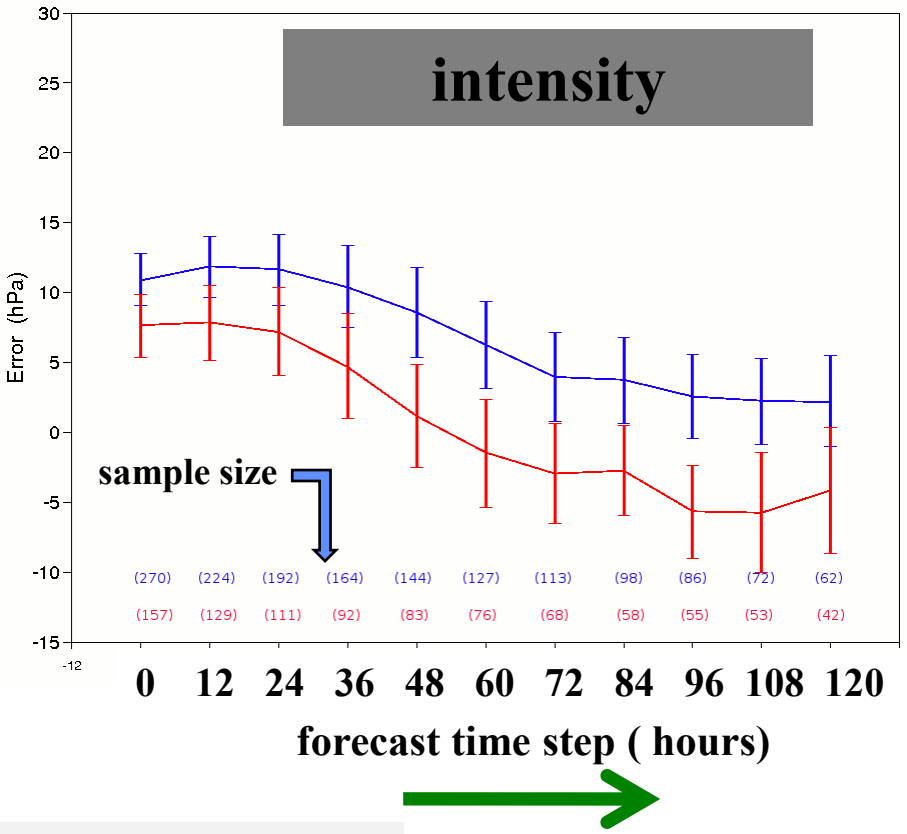
TC forecast performance T799 v T1279

(~25 km) (~16 km)

Tropical cyclone mean position error
fc period [20091004 to 20100121]



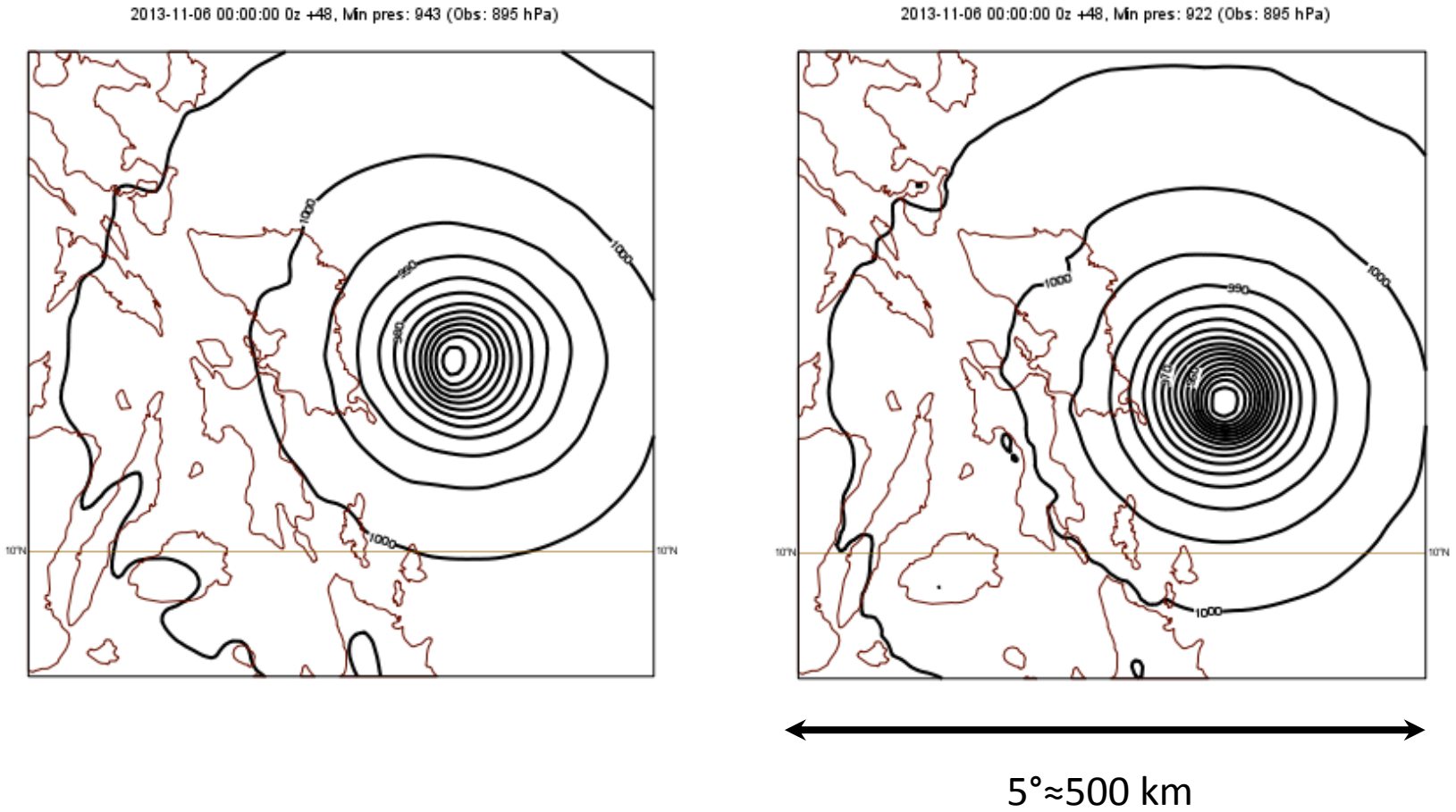
Tropical cyclone mean intensity error
fc period [20091004 to 20100121]



Error = Forecast – Obs
Obs from the best track reports

Model resolution impact – Super Typhoon Haiyan

T1279 – min 943 hPa **T+48h** **T2047 – min 922 hPa**



5°≈500 km

Courtesy of Linus Magnusson

Why is important to have an operational tracking scheme running at the Centre?

- In operational environments, when the forecaster has to look at different NWP model outputs, the analysis of TC forecast is possible only when the information (position/intensity) is delivered (displayed) in a compact format (post-processing)
- It makes possible to verify objectively the TC forecasts. Can be used for comparing different model versions (model upgrades)

- At ECMWF:
  - Operational since 2003. The switch from the current to the new tracker was successfully implemented on 2nd December 2013.
  - The algorithm runs twice a day (00 & 12 UTC) for high HRES model and ENS (51 perturbed members & control)
  - generates a track which is nothing more, nothing less than a sequence of locations of minimum (maximum) in MSLP (10m speed) every 6 hours.
  - NEW: TC tracks are produced up to 240h (previously 120h) & extra web products.

What model fields are used in the tracking scheme?

- **Surface fields**
  - Mean sea level pressure
  - Wind at 10 m
- **Upper level fields**
  - Vorticity (850 hPa)
  - Wind (multi-levels) for steering wind
  - Temperature (multi-levels) for warm core detection

The tracker is applied to NWP output every 6 hours and allows a tropical cyclone to ‘disappear’ for 24 hours (a tropical cyclone may weaken for a short period of time when crossing an island for instance).

For more details see ECMWF Newsletter No 130:

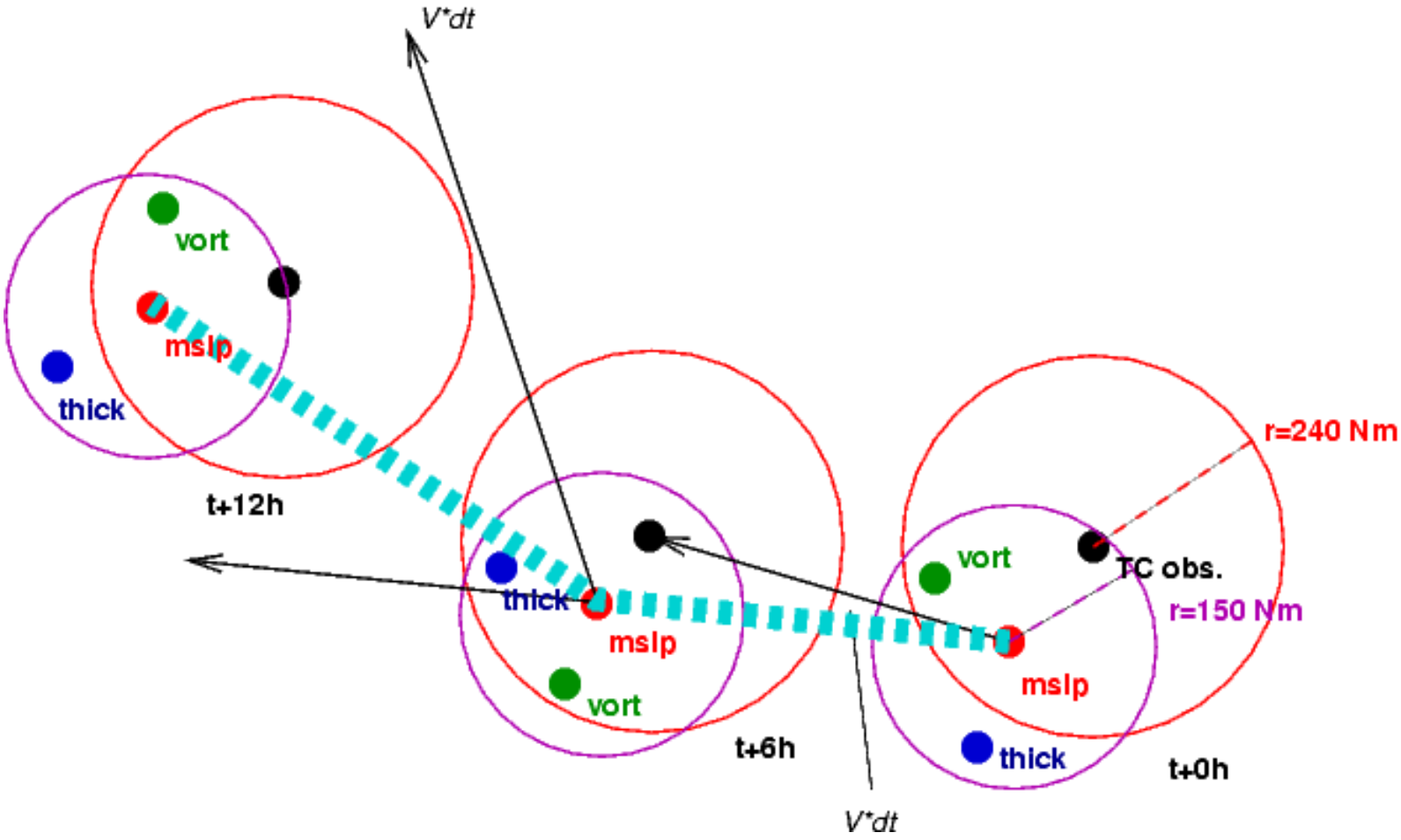
http://www.ecmwf.int/publications/newsletters/

ECMWF TC Tracker – How it works

vort 850hPa

warm core 500-200 hPa

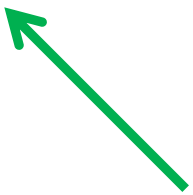
V 850,700,500,200 hPa



ECMWF

Tracker output (ALSO available in BUFR format)

Lat	Lon	ENS member (1, ...,51)	fc date	hour	mslp
36.94	-38.96	1	20121001	0	988
36.13	-39.4	1	20121001	600	997.6
35.4	-38.89	1	20121002	1200	999.7
35.09	-38.54	1	20121002	1800	999.6
34.52	-37.83	1	20121003	0	1005.6
33.99	-36.13	1	20121003	0600	1006.1
34.75	-33.02	1	20121004	1200	1003.6
37.2	-29.58	1	20121004	1800	995
36.8	-38.7	2	20121001	0	989
.....					
36.93	-38.96	52	20121001	0	987.9
36.52	-39.09	52	20121001	600	986.9
36.02	-39.12	52	20121001	1200	992.6
35.61	-38.91	52	20121001	1800	993.6
35.37	-38.45	52	20121002	0	994.6

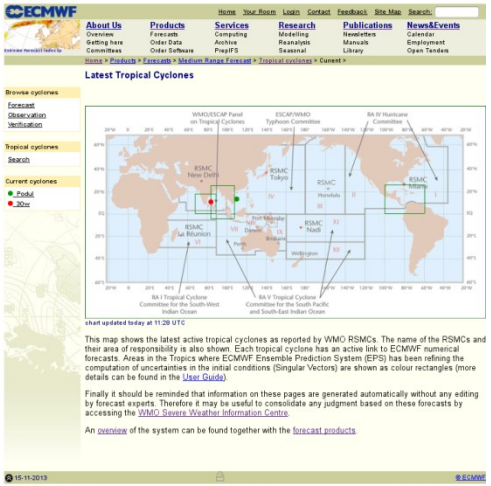


HRES model

Where can I find the web products?

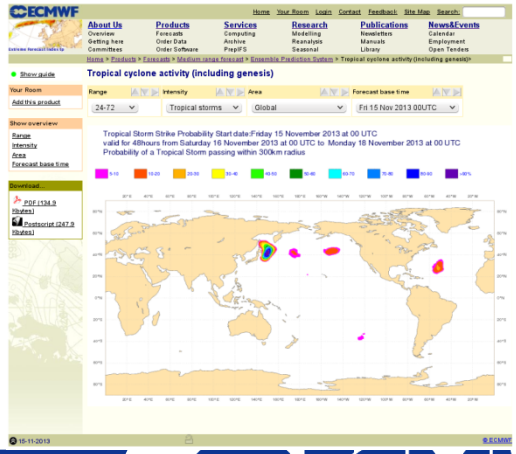
- Whenever a Tropical Cyclone is observed at the start of a forecast

  http://www.ecmwf.int/products/forecasts/d/tccurrent



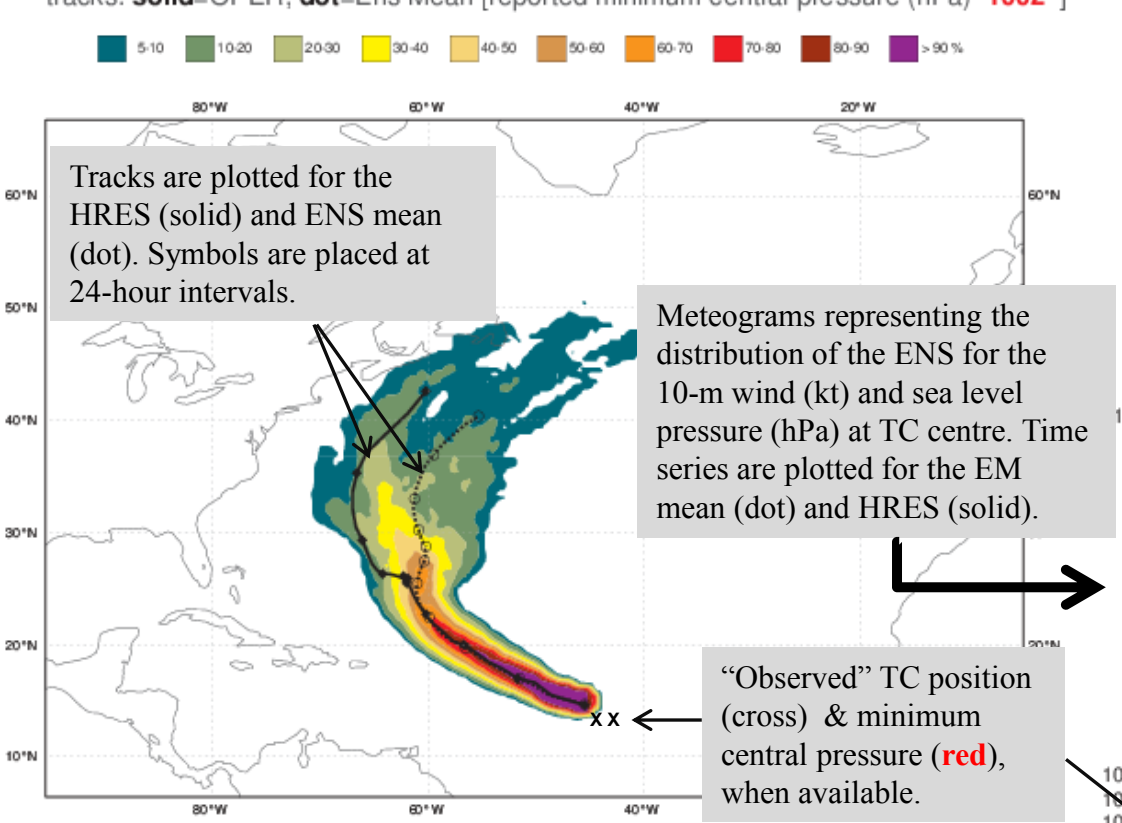
- Whenever there is Tropical Cyclone activity in the forecast

http://www.ecmwf.int/products/forecasts/d/charts/medium/eps/genesis/ta_genesis/



TC Products – Part I

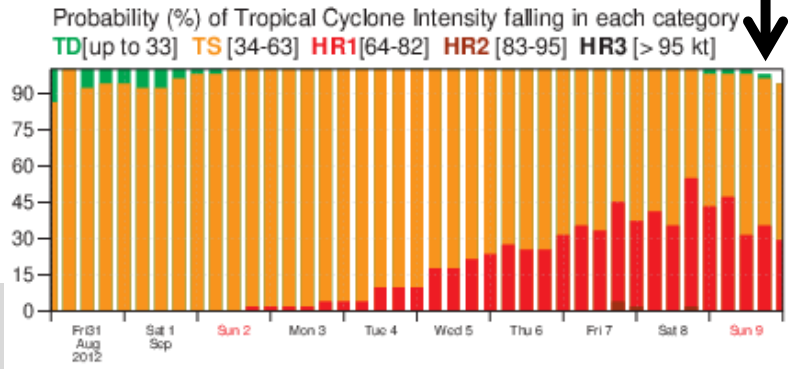
Intensity probability is the fraction of the number of ENS members (relative to the total number of ENS members which held the feature) falling into each of the 5 intensity categories, at 6-hours interval up to 10 days.

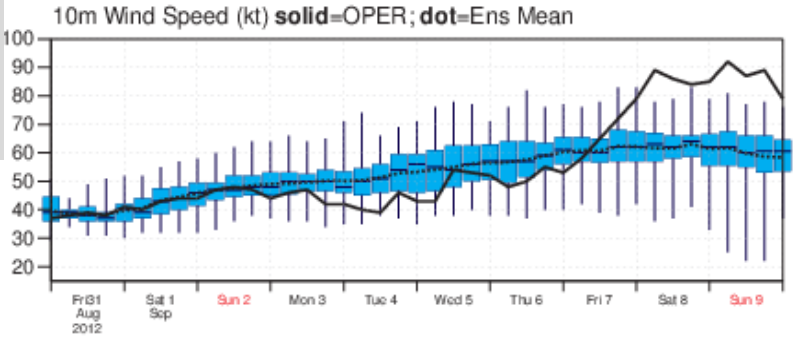


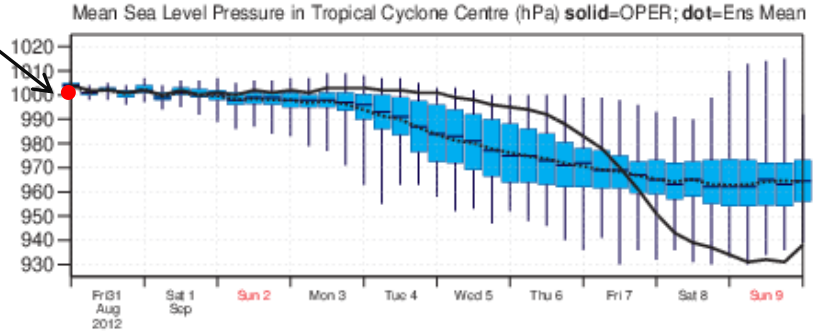
Tracks are plotted for the HRES (solid) and ENS mean (dot). Symbols are placed at 24-hour intervals.

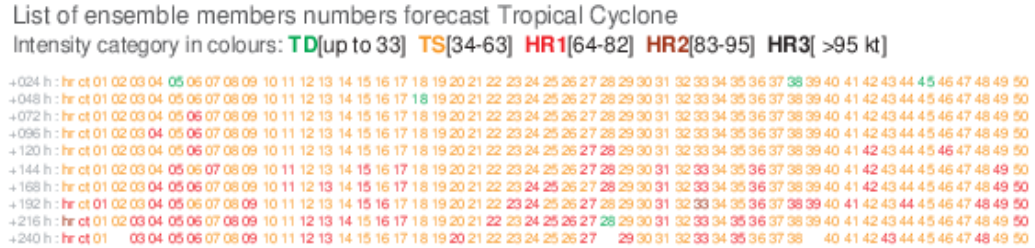
Meteograms representing the distribution of the ENS for the 10-m wind (kt) and sea level pressure (hPa) at TC centre. Time series are plotted for the EM mean (dot) and HRES (solid).

"Observed" TC position (cross) & minimum central pressure (**red**), when available.

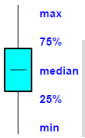






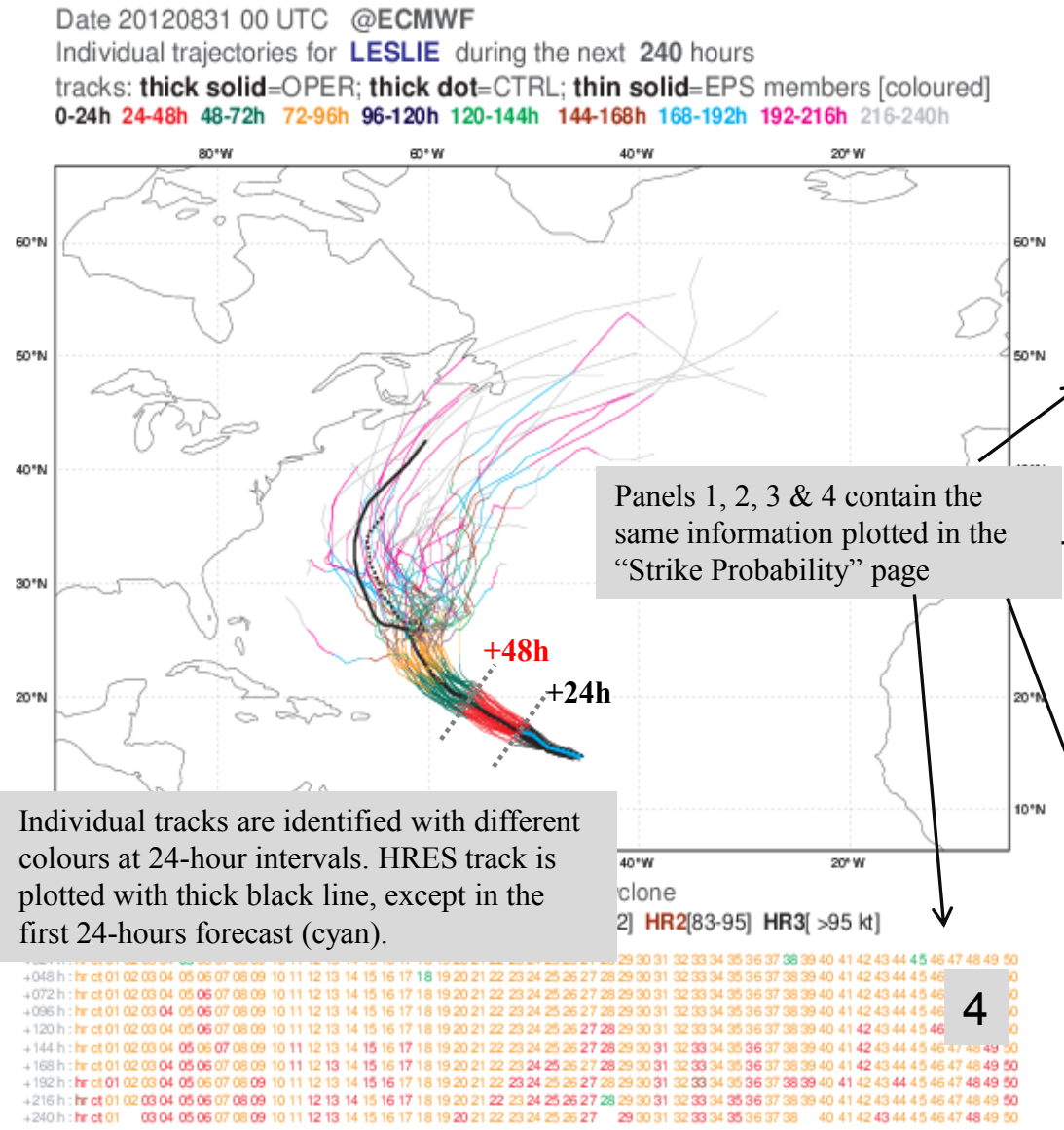


Snapshot of ENS members (numbers) tracking the storm together with intensity (colours), at 24-hours intervals. HRES and Control models are labelled 'hr' and 'ct' respectively.



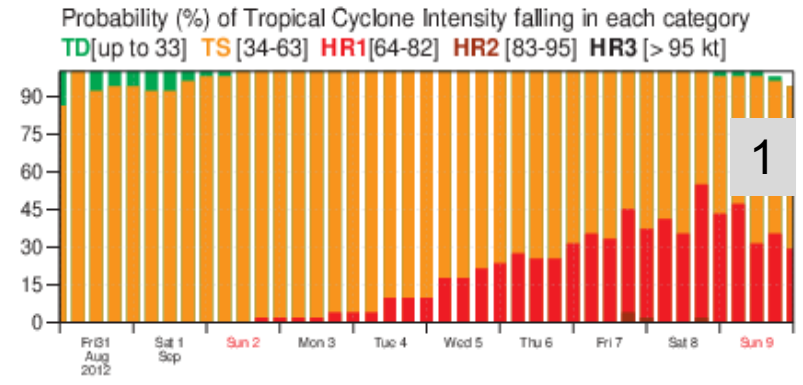
box-and-whiskers plot representing the 5 quantiles of the ENS distribution

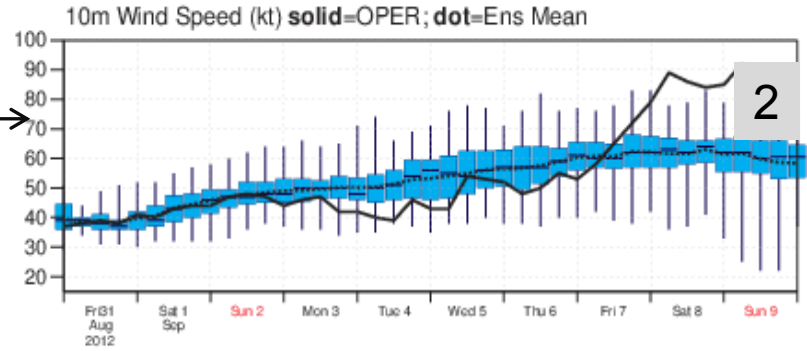
TC Products – Part II

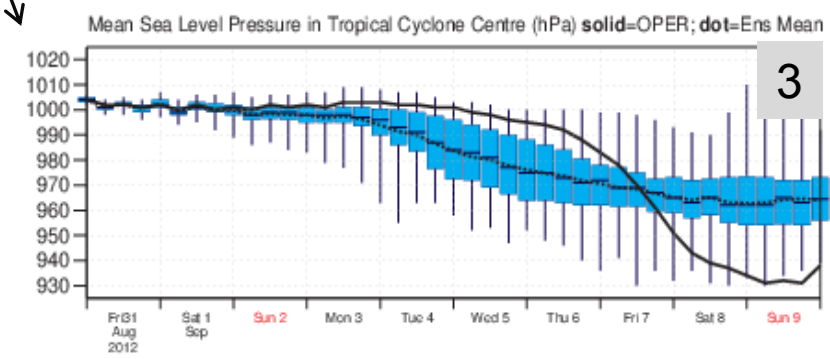


Individual tracks are identified with different colours at 24-hour intervals. HRES track is plotted with thick black line, except in the first 24-hours forecast (cyan).

Panels 1, 2, 3 & 4 contain the same information plotted in the "Strike Probability" page

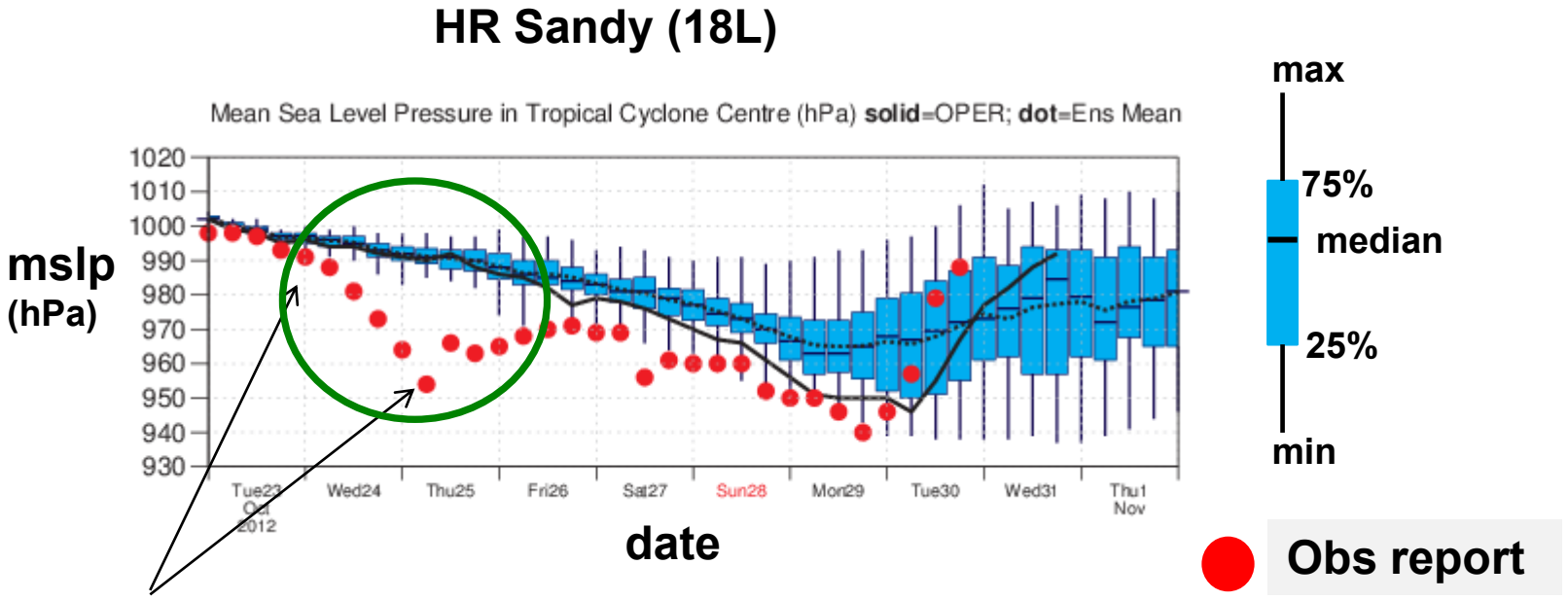






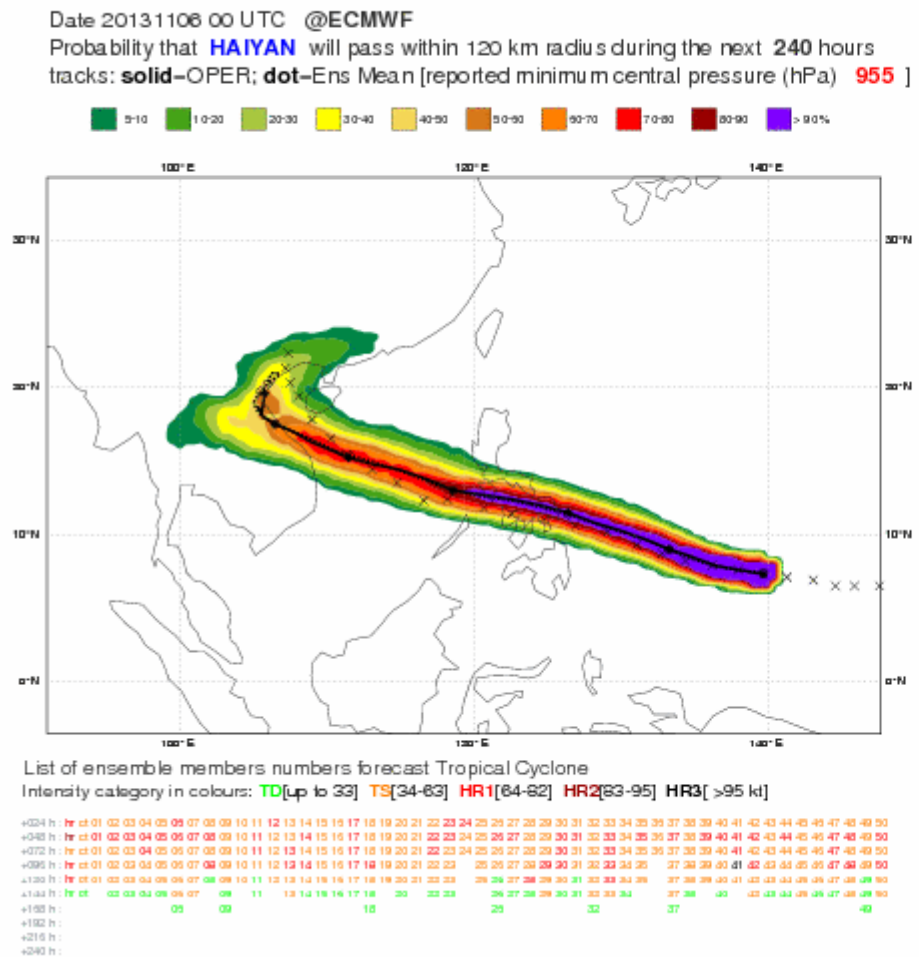
TC intensity forecast – on going problem

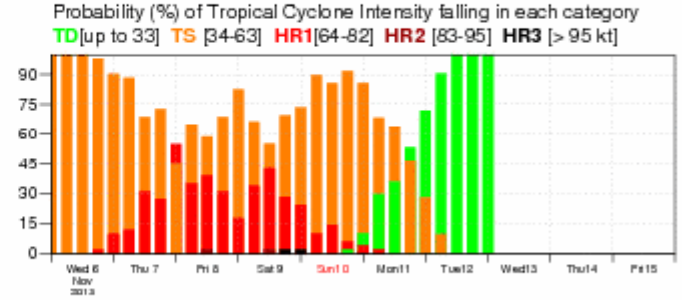
- In general , rapid intensification of TCs is still poorly handled by the current global models

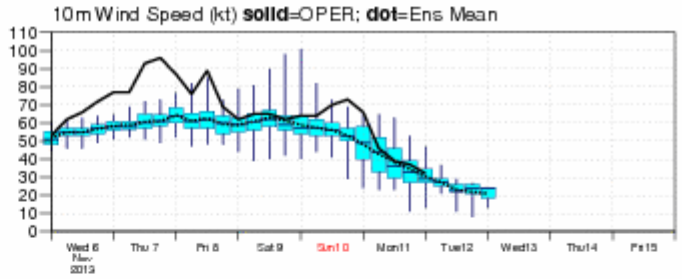


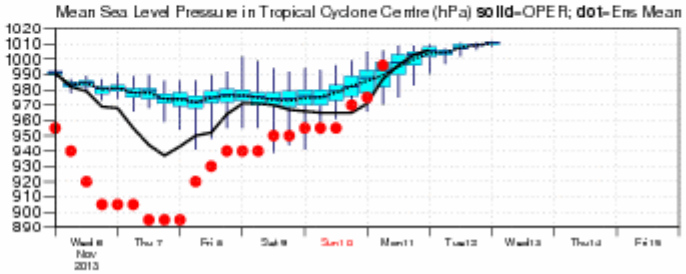
Rapid intensification
~40 hPa in 30 hrs

Haiyan 2 days before landfall

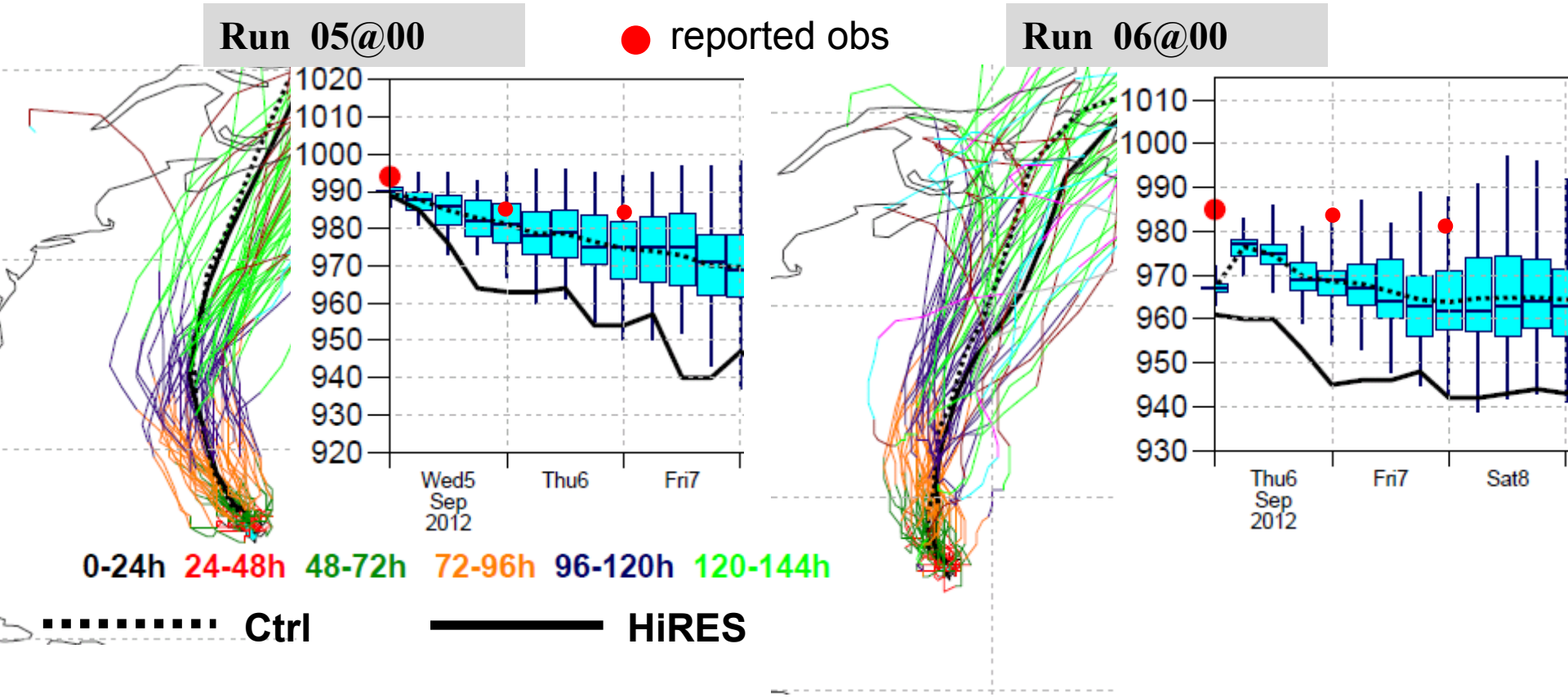








Too intense TC (12L Leslie) analysis and forecast due to non couple ocean-atmosphere model

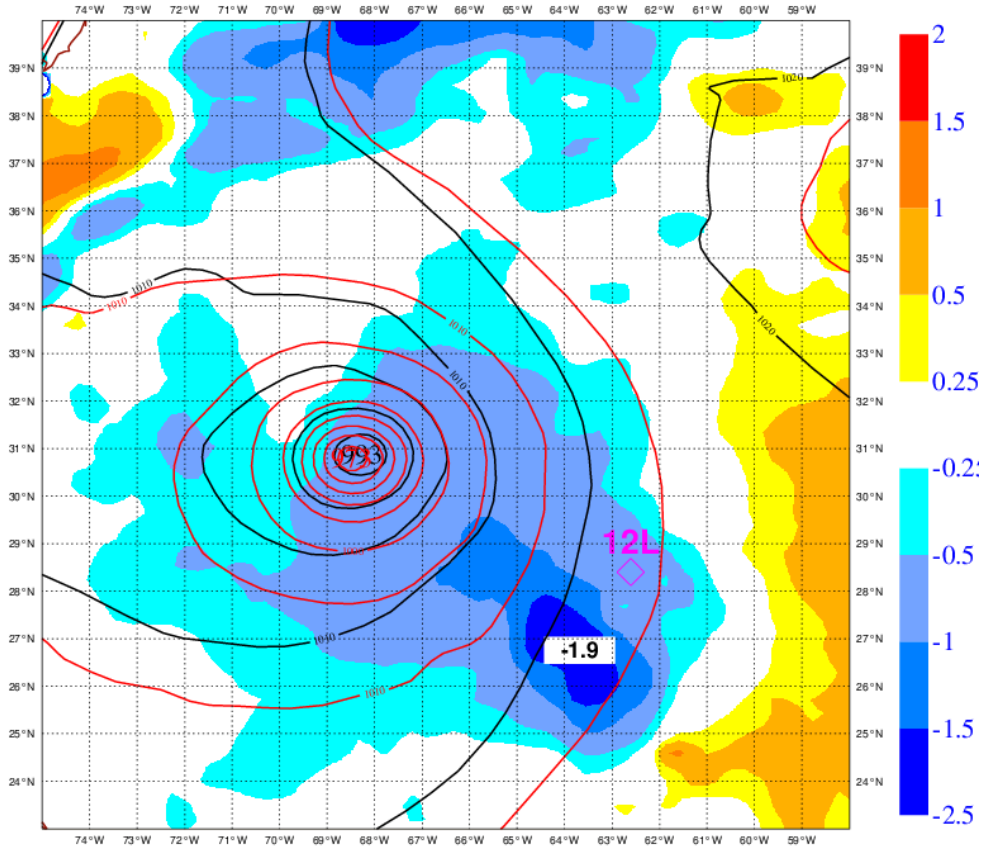


Each line represents an individual TC track ENS member (colours change every 24h interval)

The individual tracks suggest a very slow moving storm during the first days

The HiRes analysis shows a too deep storm between 6 and 8th September

Coupled ocean and atmosphere (cont...)



03 Sep 12 UTC +120h VT: 08 Sep 12 UTC

Control: operational T639 (constant SST anomaly)

Experiment: coupled ocean-atmosphere model

contours: MSLP (hPa)

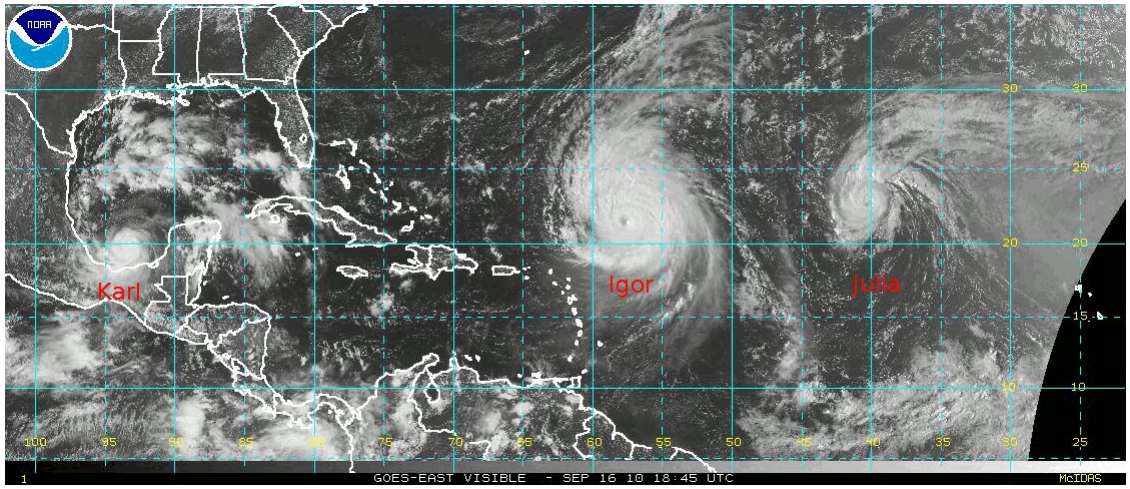
shaded: SST (K) difference (Exper-Ctrl)

Minimum Central Pressure:

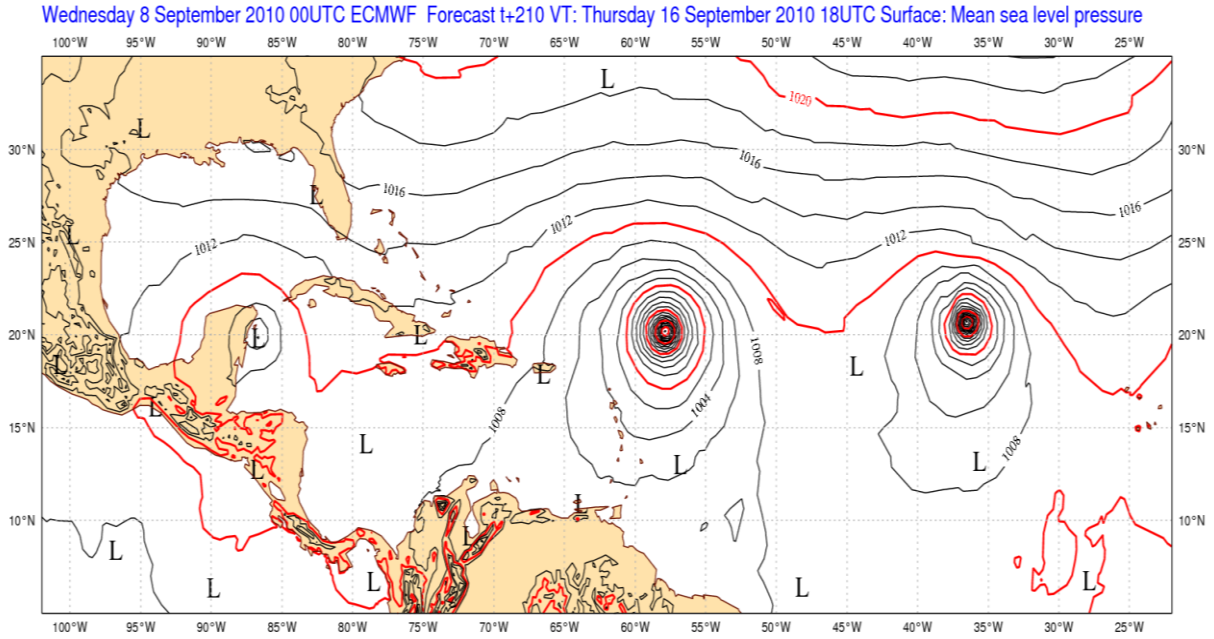
993 hPa (Experiment)

973 hPa (Control)

Forecast period of enhanced Hurricane Activity, 9 days ahead

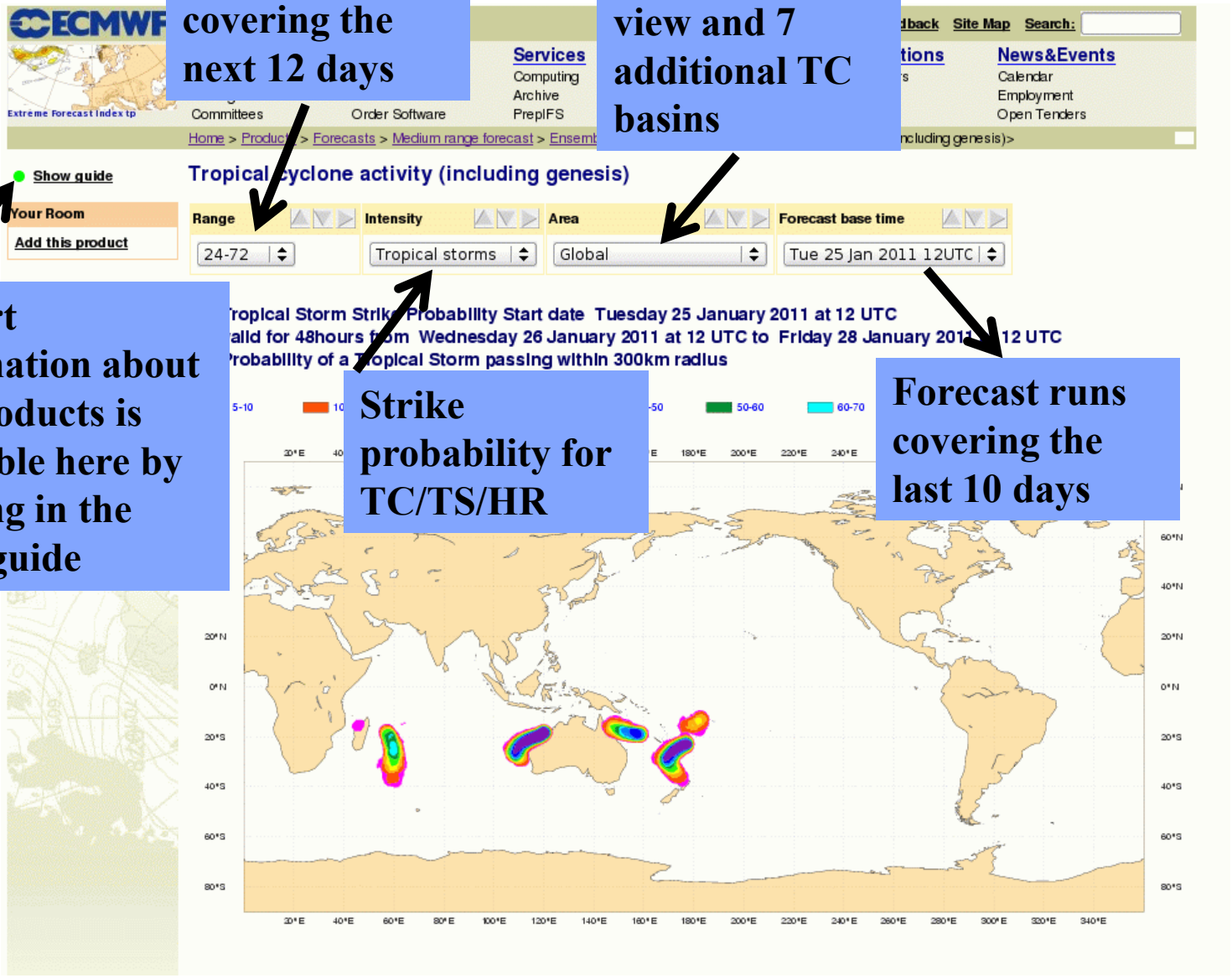


Goes-East visible image
16 September 18 UTC



T+210 h T1279
Forecast MSLP

Tropical C…ctivit…edium Range EPS



Forecast performance

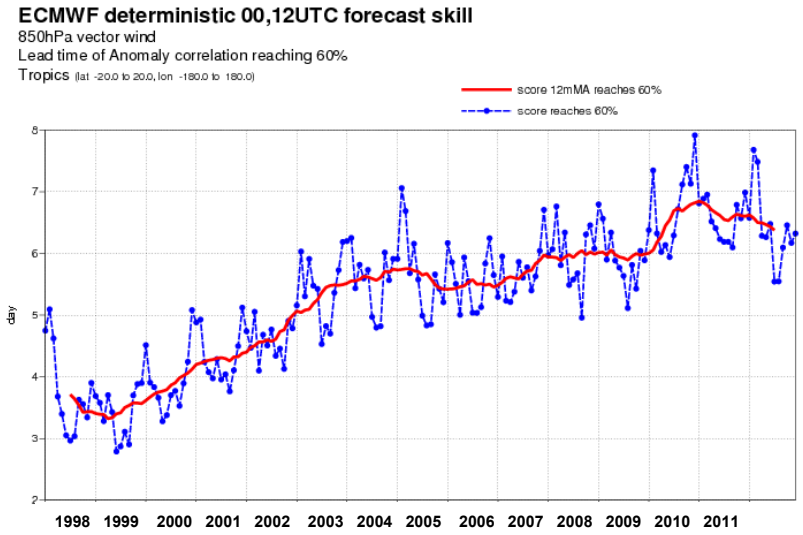
The forecast performance for TCs is checked regularly and compared with the previous years for the Global HRES model and ENS. The results are reported to the Technical Advisory Committee★ every year.

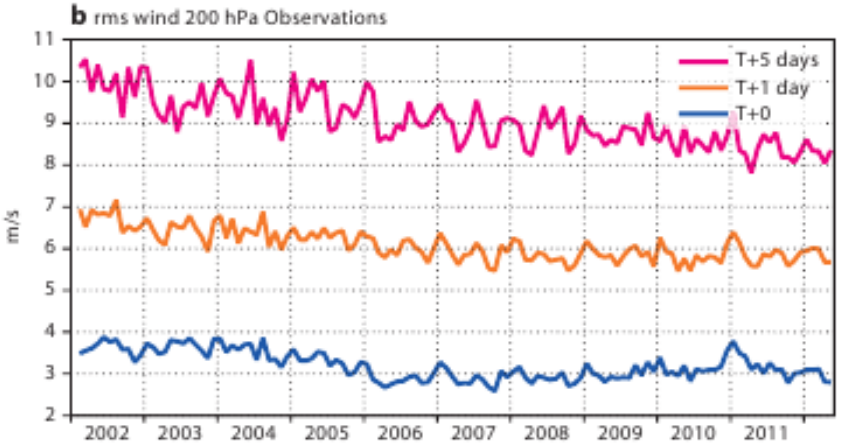
- Mean position error for HRES, Control models and ENS mean
- Mean intensity error (ME)
- Mean speed error (ME) for HRES
- Reliability and ROC for the Strike Probability Products
- ENS Spread & EM Error

★also available in technical memoranda document

http://www.ecmwf.int/publications/library/do/references/list/14

How accurate are the TC forecasts from ECMWF (Part I)?





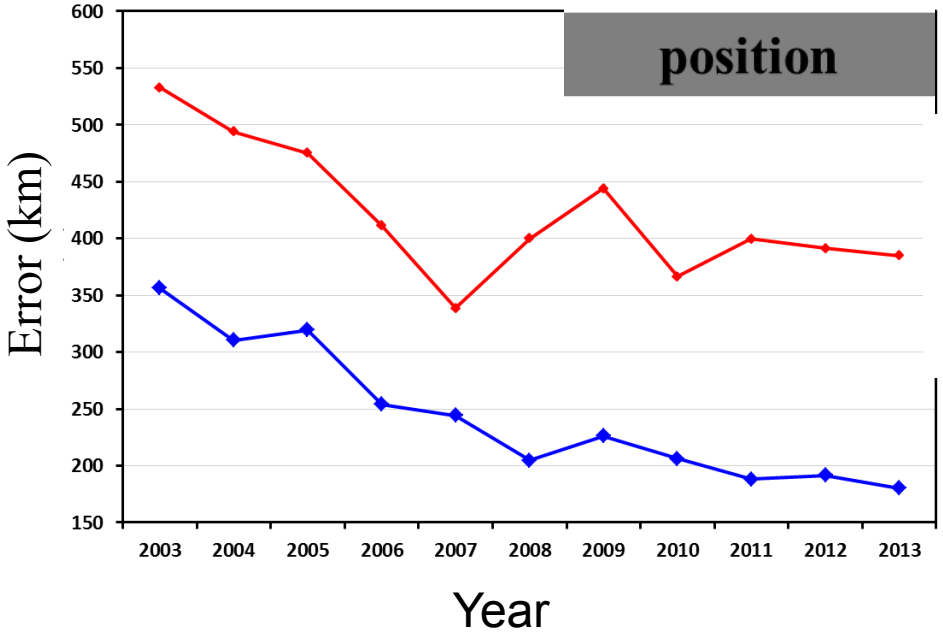
Lead Time of ACC 60% winds 850 hPa

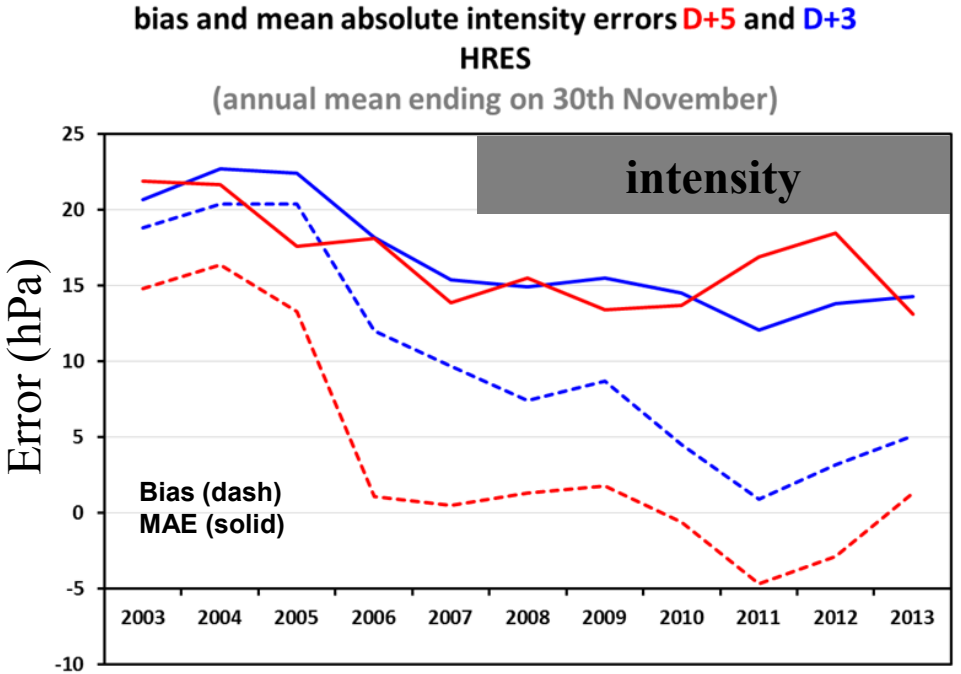
RMS winds 200 hPa (against observations)

A performance gain of ~2.5 days since early 2000 for winds at 850 hPa

How accurate are the TC Fcs from ECMWF (Part II) ?

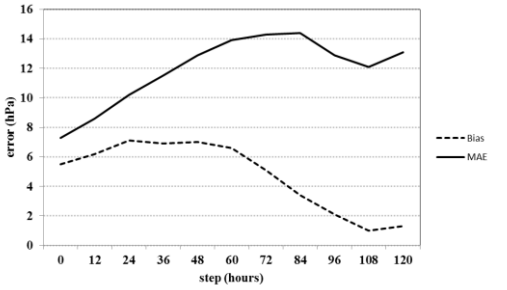
HRES verification (12 month means ending on 30 November)





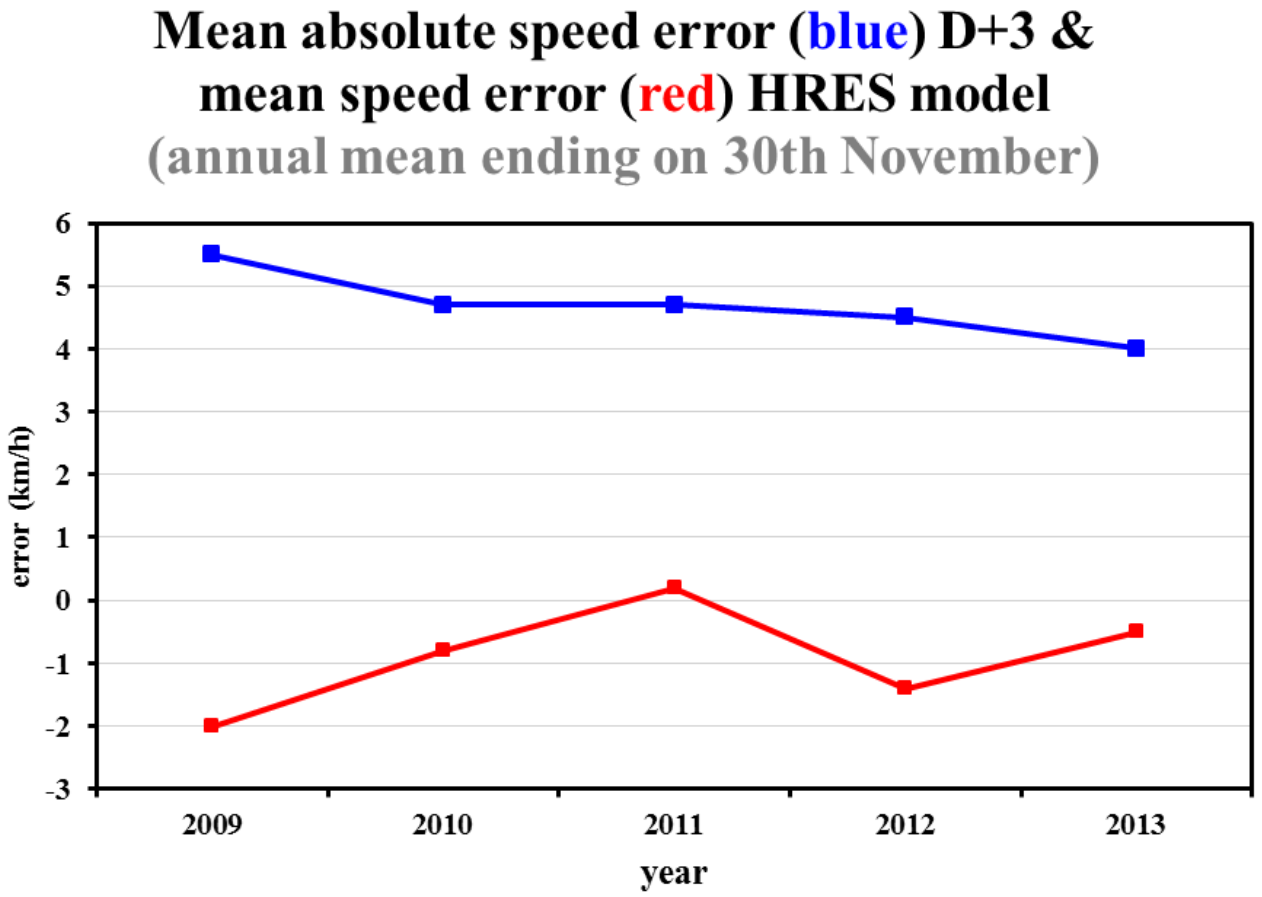
Error = Forecast – Obs

Obs from the best track reports



ECMWF

On average TCs move slower in the model (Part III)



How do we performed against the other NWP Centres (Part IV)? source: Hong Kong observatory

- 2011 verification results
- ECMWF is clearly best model
- ECMWF is comparable to or better than the multi-centre ensemble mean ("NWP ensemble")

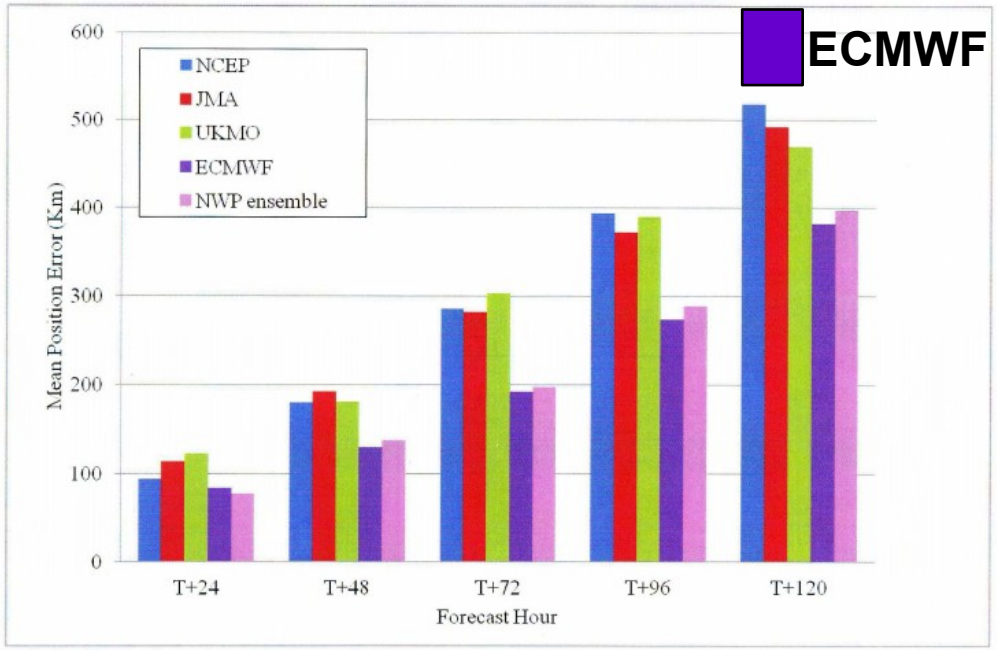
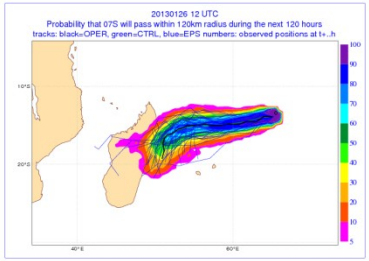


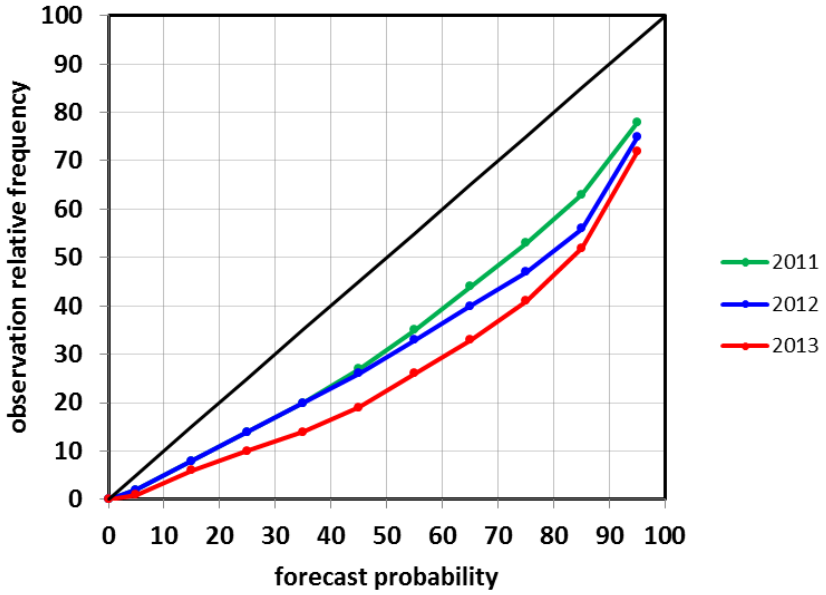
Figure 7. Mean position errors of forecasts from the NWP ensemble and the respective member models for T+24 to T+120 in 2011.

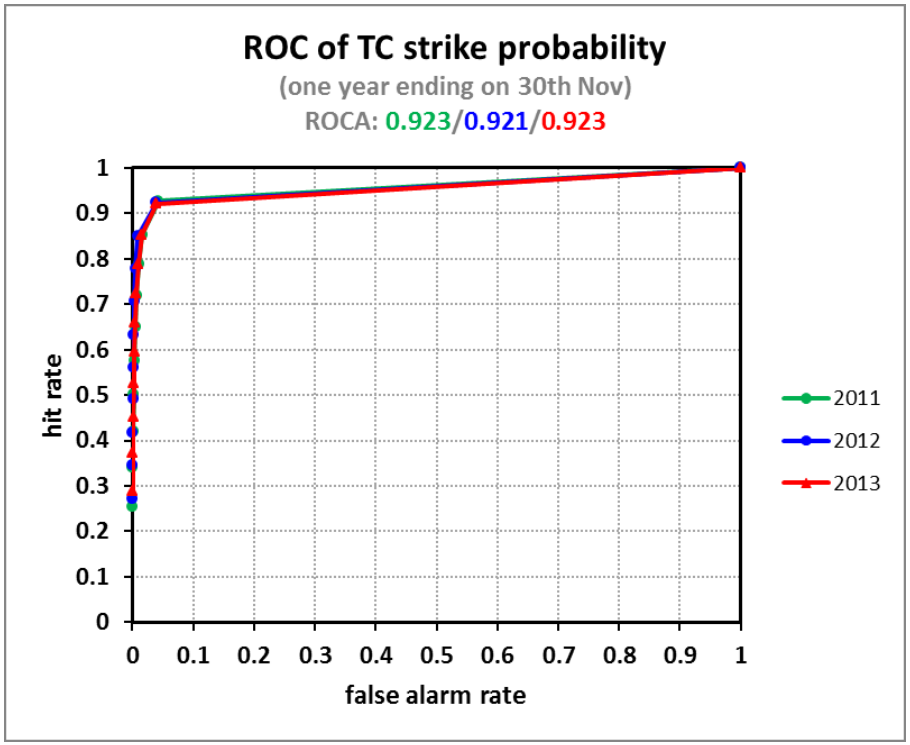
14

Verification of the ENS Strike Probability product (Part V)

Strike probability of TC within 120 km in the next five days



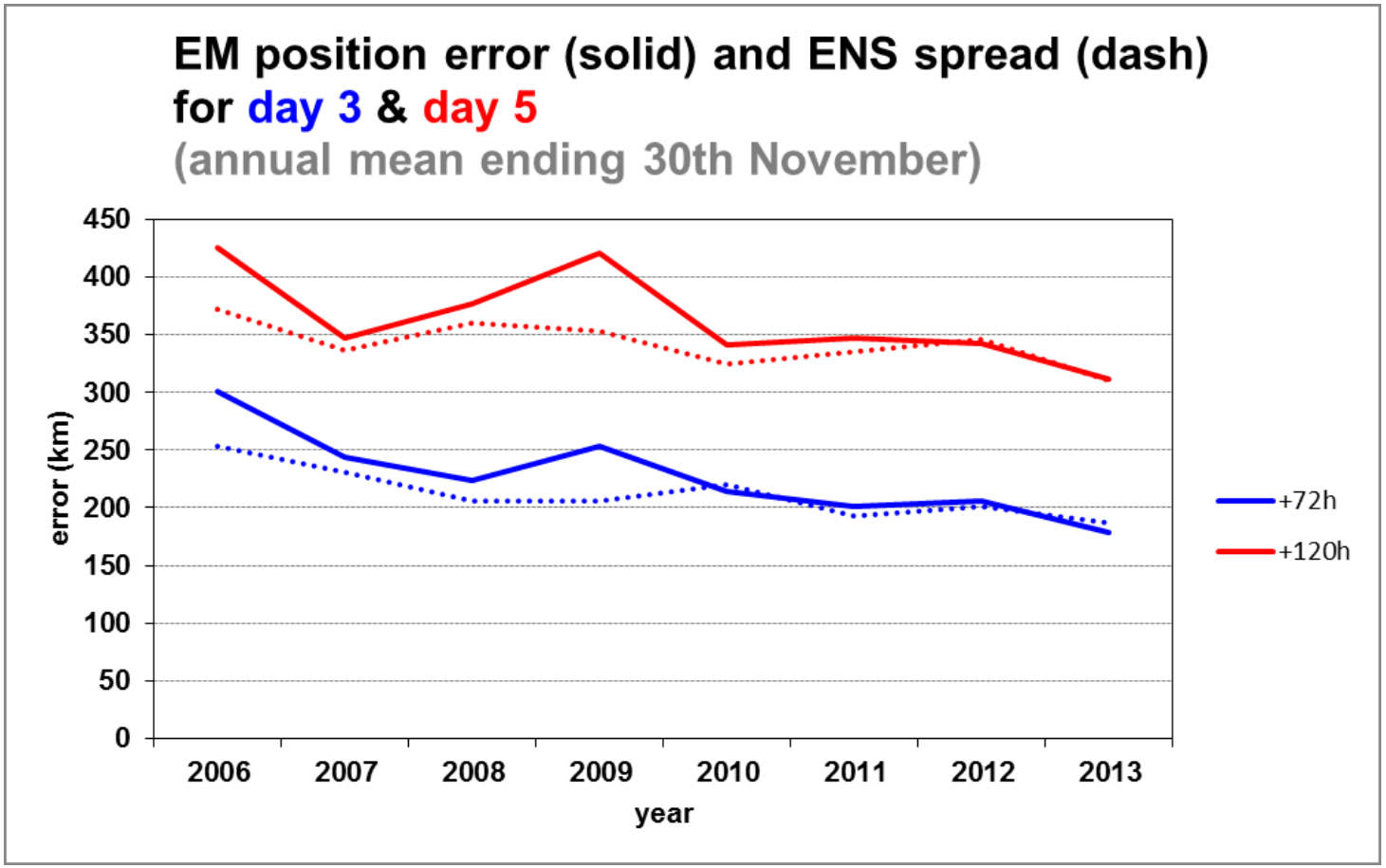




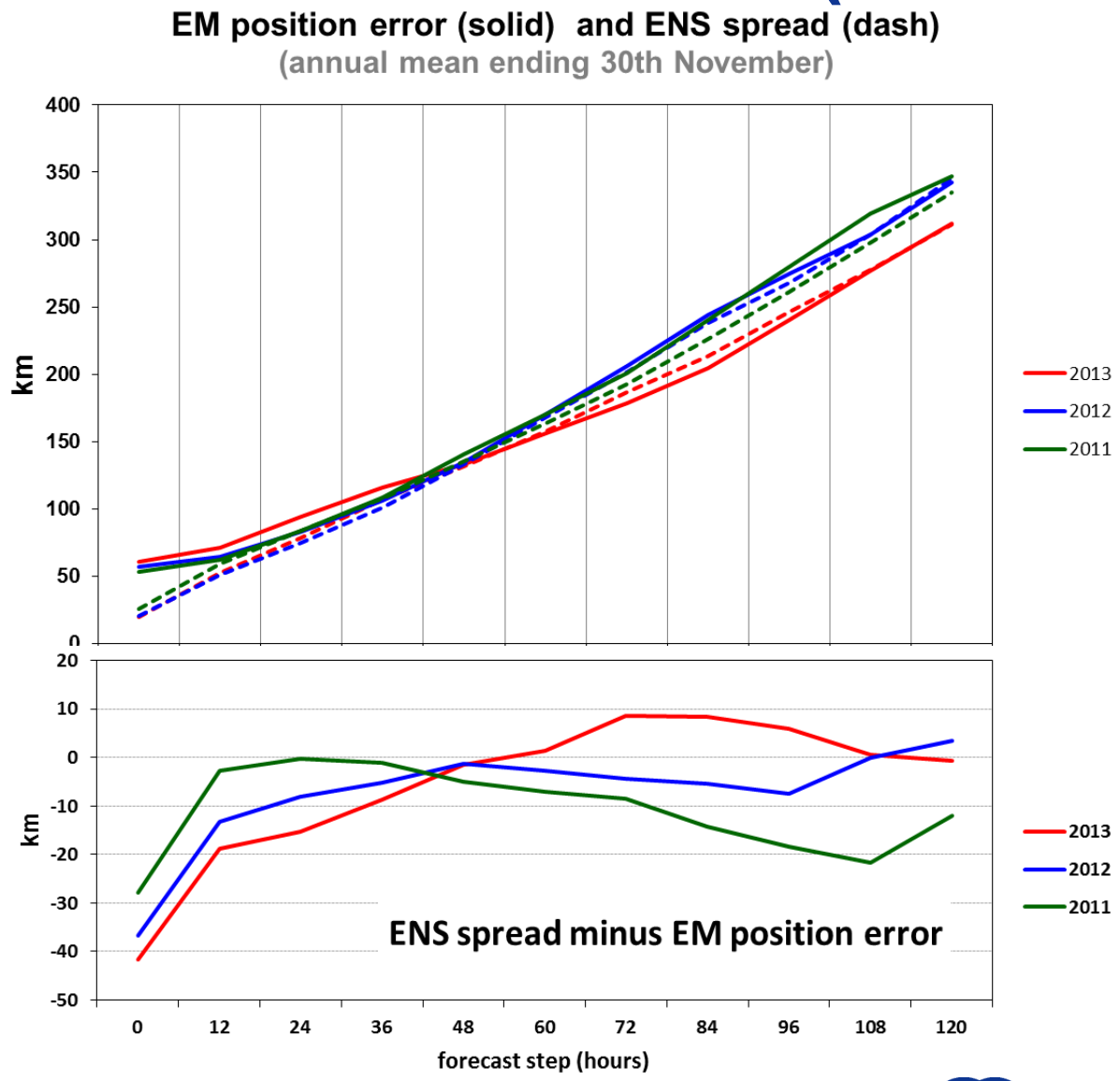
ECMWF

ENS SPREAD & EM ERROR (Part VI)

A calibrated ENS should provide consistency between the EM error and spread.



ENS SPREAD & EM ERROR (Part VII)



QUESTIONS?